Driving Large LCDs With LCD Peripheral of the MSP430

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MSP430

ABSTRACT

The 4xx family of MSP430™ devices has two different types of integrated LCD drivers, namely the LCD controller and the LCD_A controller.

The 6xx family of MSP430 devices also has two different types of integrated LCD drivers, namely the LCD_B controller and the LCD_C controller.

This application report focuses on the LCD controller, but the principles shown here apply to all versions.

The LCD controller is designed to support various LCD glasses such as Static, 2-Mux, 3-Mux and 4-Mux. The analog drive circuit in the LCD controller supports generation of 1/2 bias and 1/3 bias waveforms for driving two, three, and four backplane multiplexed LCD glasses. The bias voltages are derived directly from external high resistance potential dividers and switched to the appropriate segments by the internal analog switches in the LCD controller. This scheme works well with small LCD segment sizes commonly used in portable instrumentation. However it gets tricky when driving multiplexed LCD glasses with a digit size greater than approximately 0.75 inch. This application report shows how to drive such large LCD segments with the desired drive levels.

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1 Example MSP430 LCD Drive Circuit

LCD glasses require an ac voltage to polarize the liquid media in the glass to provide a segment on or off effect. The LCD controller in the MSP430 generates this ac voltage in conjunction with LCD drive frequency (f_{LCD}) generated by the basic timer in the device. The generated ac voltages are switched to the segment lines by analog switches, and the backplane is driven by the common lines. The LCD segments connected between a segment line and the common can be modeled as a capacitive load to the ac drive as shown in Figure 1. In this example, a 1/3 bias LCD glass is shown.

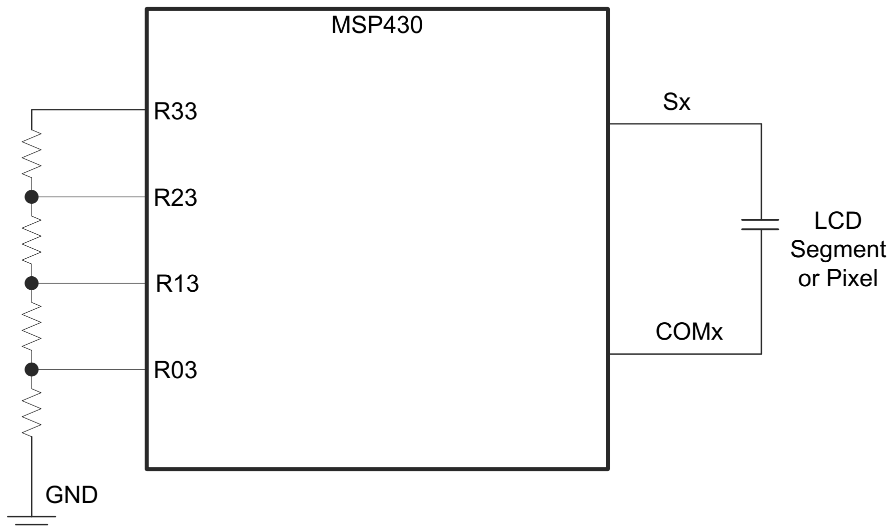

Figure 1. Electrical Model for an LCD Segment Connected to MSP430

For detailed description of the LCD controller, refer to References [1] and [2].

The LCD segment is driven by a square wave generated by the driver. The frequency of the square wave is programmable by the user and must be selected to match the LCD glass specifications. Usually it is 60 Hz to 100 Hz. The frequency of the drive waveform affects the current consumption because of the capacitance charge and discharge current flowing through the equivalent capacitance of the segments. The RMS current flow is given by V × C × 2πf, where C is the capacitance of the LCD segment, V is the RMS drive voltage across the segment, and f is the frequency. To achieve lowest current operation, it is important to keep the LCD drive frequency close to the minimum recommended frequency of the LCD glass.

Figure 1 shows a simple resistance-based potential divider that is used for generation of the bias voltages that are required for the LCD drive. The values of these resistors depend on the LCD segment size and the drive frequency. The values of these resistors can be calculated if the equivalent LCD segment capacitance, drive voltage amplitude, and the frequency are known.

The charging of the segment capacitance is exponential and the time taken for the segment capacitance to charge to a voltage level close to the drive voltage amplitude will take about 5τ, where τ is the time constant determined by the RC, R being the value of the resistance in the bias voltage generation network. Because the R ladder is connected between V_{CC} and GND, there is a continuous current leaking through the network that adds to current consumed by the LCD driver. Increasing the resistor values not only reduces the current consumption but also reduces the LCD contrast, because the RC time constant becomes larger and the segment capacitance charge never reaches close enough to the maximum voltage. This results in a trade off between best LCD contrast and the current budget that is allocated in a battery-based application. In typical hand-held battery-based applications, 680-kΩ resistors offer good contrast and low current consumption for small LCD glasses.

The LCD driver also offers contrast control to manage the drive level for optimal contrast of the LCD glass. Contrast control is done by the resistor connected between R03 and GND. The voltage at the R03 node is the virtual reference voltage from which the effective LCD drive voltage is measured. Increasing the R03 value reduces the effective drive voltage, thereby reducing the LCD contrast. The voltage at this node can also be controlled by stepped voltage levels derived from an on-chip DAC, PWM DAC, or R-2R type DAC involving two or three general-purpose I/O pins. Additionally, the ambient temperature can be measured by using either the on-chip temperature sensor or an external thermistor to adjust contrast automatically according to the ambient temperature. It is important that the LCD glass drive voltage specification must be slightly lower than V_{CC} to achieve contrast control. In most cases, the LCD contrast can be set at the maximum with a 0-Ω jumper connected from R03 to GND.

The R33 node is internally switched to V_{CC} of the device. The R23 and R13 nodes are derived from the resistor-based potential dividers. When large resistor values are used with larger segment size displays, the R23 and R13 nodes tend to have increased voltage ripple, because of overloading by the larger segment capacitance. Too large a ripple manifests as poor contrast or undesirable LCD segment ghosting. Section 2 shows how this effect can be minimized to achieve improved contrast for large LCD glasses. It is also mandatory to have tight-tolerance potential divider resistors for the node voltages to be symmetrically divided. Any large deviation in the symmetry could also result in poor contrast or ghosting.

2 Methods of Improving LCD Contrast for Large Glasses

A simple approach to minimize the ripple on the R23 and R13 nodes is to provide capacitors between the node and GND as shown in Figure 2. Capacitor values of 1 µF to 10 µF can be considered. Sometimes it may also be required to reduce the values of the resistors in the resistor ladder. It is possible that some large glasses may require resistors as low as 33 kΩ. This reduced resistance results in higher current consumption.

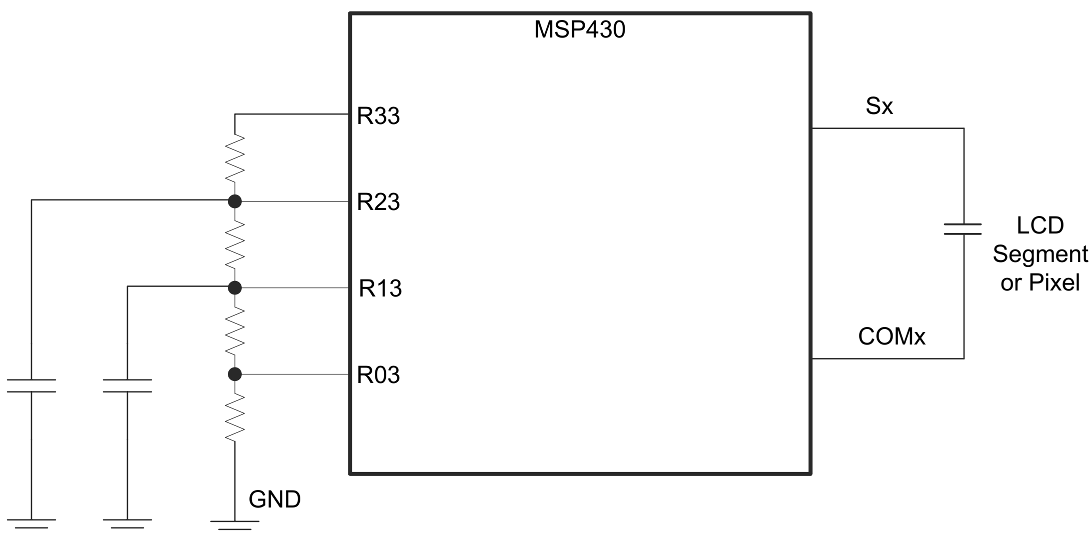

Figure 2. Using Capacitors to Reduce Ripple on the Nodes

A better approach would be to use low-current opamps as buffers at the nodes. This approach provides a very stable node voltage and offers a dramatic improvement in the contrast of the large size LCD segments that have high capacitances. The trade off is slightly increased current consumption. Figure 3 shows a circuit that uses two opamps.

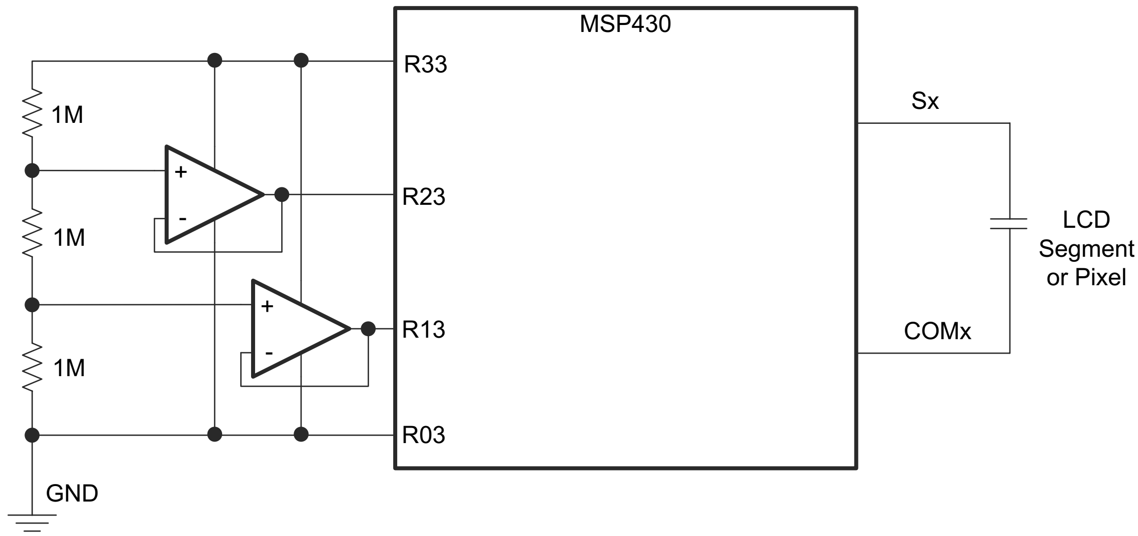

Figure 3. Using Opamps to Buffer Node Voltages

A dual opamp such as TLV2242 or TLV2402 with approximately 1-µA quiescent current can be used in this scheme. The circuit shown in Figure 3 does not support contrast control. In most cases, contrast control may not be required as large LCD segments must be driven with maximum amplitude. If contrast control is required, a third opamp may be used to buffer the voltage at node R03 instead of connecting it directly to GND.

3 References

1. *MSP430x4xx Family User's Guide* (SLAU056)

2. *MSP430x5xx and MSP430x6xx Family User's Guide* (SLAU208)

2. TLV2242 data sheet (SLOS329)

3. TLV2402 data sheet (SLOS244)

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